THE COMBINED HARVESTER-THRESHER IN OHIO In 1928

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The use of the combined harvester-thresher in Ohio is a very recent development. The idea of harvesting and threshing grain in one operation is not new. As early as 1828 there are records in the United States patent office of the granting of a patent for a combined harvester-thresher. Several other early attempts to develope the combine were made but not until 1890 were there any manufactured for general distribution in the United States. Until the beginning of the present decade but very few combines had found their way east of the Rocky mountains. By 1926 a few were being tried east of the Mississippi river.

In 1926 there were known to be 3 combines in Ohio, in 1927 the number increased to 38 and by the close of 1928 harvest season the total number of which we have some record had grown to 87. Much general interest is being aroused among farmers in Ohio in the operation of the combine and in the practicability and dependability of its use with our type of farming and weather conditions.

To obtain information on the location, operating costs, and problems of the combine in Ohio, a study was made of the combines in Ohio, Records were secured from farmers who operated these machines during the 1928 season. Information was collected as to the location of 87 combines in the state and 75 of the combine owners were personally interviewed. The present is a preliminary report. It is planned to continue the study after the harvest of the 1929 crop.

The present report is one phase of a study of the combine-harvester in Ohio which is being carried on in cooperation with the Department of Agricultural Engineering.

Location of Ohio Combines

The combines in Ohio in 1928 were almost all located in the level or gently rolling grain producing areas in the western half of the state. Of all the combines located in the survey Wood county had 17 which was more than twice as many combines as any other county in the state, and it, together with the adjoining counties, accounts for over one third of the combines in the state. Only two combines, one in Wayne and one in Muskingum counties, were located in the eastern half of Ohio in 1928 (See map for location).

Size and Type of Combines in Ohio

Of the 75 combine owners interviewed 3 machines were purchased in 1926, 28 machines in 1927 and 44 in 1928. Of the 44 machines that were purchased in 1928, 39 were new and 5 were used machines. Table I shows that 13 of the combines included in the study have less than a 10-foot cut, 45 are 10-foot cut, 11 are 12-foot cut, and 6 are 15 or 16-foot cut. All of the combines with less than a 10-foot cut were used prior to 1928. In 1928 there were in Ohio, 17 machines larger than 10-foot cut and of these all but 4 were purchased in 1928. Eleven of the combine owners interviewed have combines of the power take off type, and 64 have auxiliary engine type. All of the power take off type machines were used during the 1927 harvest season.

Original Cost of the Combine

The first cost of the combine varies with the size of the machine; ranging from an average of $1300 on the less than 10-foot size to an average of $2275 on machines of 15 and 16 foot size. The price not only varied with the size but also for the same size, depending on the make of the combine. Eight different makes of combines were in operation in Ohio during the 1928 harvest season.

Table I.

Combines by Size and Price Owned by the Farmers Interviewed In 1928

Width of Cut	Number of Combines	Average Price
Less than 10 ft.	13	$1300
10 ft.	45	$1450
12 ft.	11	$1950
15 and 16 ft.	6	$2275

Size of Farms Operated by Owners of Combines

Up to the present time the ownership of the combine has been largely among the farmers who are operating farms that are considerably above average in size. An average of 385 acres was operated by each of the farmers owning a combine either in partnerships or individually in Ohio in 1928. Eleven of the 75 combines in the study were owned cooperatively, 9 machines by 2 partner combinations and 2 machines by 3 partner combinations. An average of 212 acres was operated by each of the farmers owning machines cooperatively, and a total of 464 acres are operated for each combine owned cooperatively. Three combines are operated entirely as custom machines and owned by men who did no farming.

Table II.

Acres Operated by a Farmer or Group of Farmers Owning a Combine, 1928

Acres Operated Per Combine	Number of Combines
150 acres or less	6
151 to 250	15
251 to 350	16
351 to 450	9
451 to 550	8
551 to 650	5
651 to 750	5
751 acres and over	8

Acres Harvested Annually

In 1928 an average of 192 acres of small grain was harvested for each combine visited, and for those combines visited, that were used both in 1927 and 1928 an average of 185 acres was harvested by each machine in 1927. The smallest acreage of grain harvested in 1928 by any combine was 35 and the largest acreage was 630.

In Table III the acres of various crops harvested with combines included in the study are given for 1927 and 1928. The Ohio combine operator in comparison with the west and middle west operator has had a wider variety of uses for the combine because of our diversified type of farming. There were almost three times as many acres of grain combined in Ohio in 1928 as in 1927. The total acreage of wheat combined in 1928 was, however, less than in 1927. This was due to the failure of the 1928 wheat crop. The increased acreage of oats and barley in 1928 was a result of their being used to replace to a large extent the wheat that winter killed. Both years the soybeans harvested have been approximately 1/8 of the total acreage covered, and without exception the farmers said that harvesting soybeans with a combine is the cheapest and by far the best method at the present time.

Table III.

Acres of Crops Harvested with Combines 1927 and 1928

ITEM	1927	1928
Number of combines	29	75
Avers harvested per combine	185	192
Total acres combined	5,369	14,371
Wheat	2,329	2,224
Barley	418	3,143
Oats	1,360	6,162
Soy beans	690	1,737
Buckwheat	49	353
Mixed grains		395
Red clover	112	116
Sweet clover	351	136
Miscellaneous	60	105

Rate of Harvesting

The acres covered per hour with the combine varied from less than 0.5 of an acre to over 3.5 acres per hour, while theaverage for 1928 was 1.7 acres per hour. The rate of harvest depended on several factors. From the mechanical standpoint the width of cut of the combine is very important. In the short period of the combines existance in Ohio other factors have had as great or even greater effect on the rate of the harvesting than the size of the combine. The experience and ability of the operator in handling the combine has had much to do with both the rate of travel and success. Other factors that have effected the rate of travel are the weather conditions, the condition of the grain, the length of straws taken into the combines, and the amount of green plant growth present.

Table IV.

The Acres Covered per Hour by Different Size Combines in 1928

Width Cut	Acres per Hour				
	All Crops*	Wheat	Barley	Oats	Soy beans
Less than 10-ft.	1.26	1.48	1.18	1.23	1.43
10-ft.	1.79	2.08	1.96	1.68	1.53
12-ft. and over	1.76	1.94	2.10	1.63	2.10

* Includes wheat, barley, oats, and soy beans.

Costs of Operating a Combine

The costs of harvesting grain with a combine is effected by many factors and conditions. The variation in the price of the machine, wage rates, fuel and oil prices effect the costs of operation. The condition of the grain whether standing or lodged, heavy or light crop, kind of weather, mechanical ability and experience of operator all of which effect the rate of harvest, have a big effect on the cost of operating a combine. Because of the wide variety of conditions in which combines were operated in Ohio in 1923 there is a wide variation in costs. All of the combine-owners interviewed operated their combine with two men (one man on the tractor and one on

the combine) except seven, which were operated by one man each. Two-thirds of the combines were drawn by tractors of the two plow bottom class and one-third by tractors of the 3 bottom plow class.

In determining the cost of combining grain, all costs were figured up to the point where the threshed grain is delivered at the grain spout. The cost figures do not include the labor and expense involved in moving the threshed grain from the machine to the bin or elevator. No figures were obtained on the cost of hauling the grain from the combine to bin or elevator. In 60 per cent of the cases one man was used to dispose of the grain after it was threshed, 33 per cent used two men, and seven per cent used three or more men. Both wagons and trucks were used to haul the grain away from the machine and often where one man took care of the grain two or more wagons or a wagon and truck were brought into service in moving the grain.

Approximately one man hour and one half hour of tractor labor were required per acre. The wages that each individual operator would have been required, or did, pay for harvest labor was used in determining man labor costs. A flat charge of 75 cents per hour for the use of the tractor was applied to cover all costs except fuel, oil and grease. A flat charge was made rather than a different charge for each size tractor since more than two-thirds of the tractors used were of the two bottom plow rating and the size of tractor used depended very little on size of combine. The charge for the fuel, oil, and grease consumed by the tractor, and by the auxiliary engine on the combine was made on the basis of the price and quantity reported by each individual operator. The repair costs so far have been very small because the machines are new. Man labor, tractor charge, fuel, oil, and grease for the tractor and combine, and repairs on combine make up the cash costs included in harvesting grain with a combine.

While the combine gives a decided economy in the use of labor, both in time and size of crew, there is a disadvantage, compared with other harvesting machines in that it requires a large original investment and consequently has a high depreciation and interest charge per acre. The combine has been used too short a time in Ohio, or for that matter in any section east of the Rocky Mountains, to determine the length of service to be expected under ordinary Ohio conditions. Moreover, the combine is in the process of development and a machine may decrease in value as much from becoming obsolete as from actual wear and tear. Each individual operator was asked to estimate the number of years of service that he expected the machine would give. Estimates averaged from five to twenty years but the majority believed or estimated ten years to be the life of their combine. The length of life expected apparently has little relation to the annual use, and under actual conditions the length of life will probably depend more on the ability of the operator and the care that the machine receives than on the annual use. In determining the annual depreciation charge, ten years was used as the life of the combine. An interest charge was made at the rate of 6% on the first cost for the first year of use and for the second year interest charge was made at the same rate on the value of the combine remaining after the previous years depreciation was deducted.

Table V.

Total Annual Cost For Ten Foot Cut Combines, 1928.

Acres Grain Harvested per Combine	No. of Com- bines	Cost per Combine							
		Man Labor	Tractor Charge	Fuel Combine	Fuel Tractor	Repairs Combine	Interest Deprec.	Misc. Charge	Total
Less than 100	(7)	$29.92	$30.78	$12.35	$12.33	$ .91	$225.50	$2.78	$314.57
100 - 149	(6)	47.36	55.45	20.11	26.80	.16	242.92	2.76	395.56
150 - 199	(12)	49.95	66.60	21.64	24.97	2.49	229.68	4.50	399.83
200 - 249	(6)	92.47	105.68	37.43	44.30	19.37	222.56	8.80	530.41
250 - 300	(5)	95.60	120.91	36.55	53.43	19.68	226.36	7.03	559.56
300 and over	(6)	131.04	163.80	57.33	73.71	40.95	215.82	15.56	698.21

Of the items that make up the cost of operating a combine, labor, power, fuel and repairs increase in direct proportion to the number of acres harvested. The cost per acre for these factors changes very little with an increase or decrease in the number of acres covered. The factors of depreciation and interest have been considered as items of fixed annual cost, assuming that little or no relation exists between depreciation of the com-

Table VI.

Cost Per Acre of Harvesting Grain With a Ten Foot Cut, Auxiliary, Motor Driven Combine, 1928

Item	Costs per Acre		
	Wheat (1)	Barley (2)	Oats (3)
Man Labor	$0.32	$0.32	$0.36
Tractor	.36	.39	.44
Fuel, Oil & Grease for Tractor	.15	.16	.18
Fuel, Oil & Grease for Combine	.12	.13	.14
Repairs on combine	.03	.04	.03
Miscellaneous (chore labor)	.03	.03	.03
Cash Cost	1.01	1.07	1.18
Interest and depreciation on combine	1.34	1.38	1.48
Total Cost	2.35	2.45	2.66

bine and annual use. (This may not be altogether correct, however, no better basis of charging depreciation suggested itself.) On this basis the greater the annual acreage harvested the smaller the depreciation and interest charge per acre. The effect of the total acres harvested annually and the total cost per combine are given in table V. The cost of man labor, power, fuel and repairs increase as the acres harvested increase but the yearly charge for depreciation and interest remains constant. The total cost of operating the

(1) Average of 17 combines harvesting 860 acres of wheat yielding 17 bushels per acre.
(2) Average of 25 combines harvesting 1092 acres of barley yielding 27 bushels per acre.
(3) Average of 32 combines harvesting 2033 acres of oats yielding 40 bushels per acre.

combines increased as the acres harvested increased but not in the same proportion as labor, power, fuel and repairs because the depreciation and interest charge remain fixed. But cost per acre decreases as the acres harvested increase. Table VI contains the cost per acre of harvesting grain with a 10 foot cut auxiliary, motor driven combine. The cost figures on the 10 foot size combine were used in both tables V and VI because this size combine was the most commonly used in 1928.

Old and New Methods of Harvesting Compared

In order to compare the combine method with the binder and stationary thresher method information was collected on the binder-thresher at the same time and from the same farmers that used combines. A majority of the binders owned by the farmers interviewed in the study were 7 and 8 foot size and of the horse drawn type, although a large number of the farmers were using tractors to pull their binder. A small number of the larger farms were using special 10-foot cut tractor binders previous to the purchase of the combine. The average and most common size of crew used in cutting and shocking was four to five men. On farms using tractor drawn binders the rate of harvest was 18 to 20 acres per day and somewhat less for horse drawn machines.

The per bushel charge for threshing varied from one community to the next and in the different sections of the state. The average per bushel charge for wheat was 6.2¢; for barley, 5.6¢; and 3.8¢ for oats. Four acres per hour was the average rate of threshing for wheat, barley, and oats. To make the data comparable with the combine, the labor and expense involved in threshing with the stationary separator was included up to the point where the threshed grain was delivered at the grain spout. The average size crew needed to get the grain to the machine and threshed was 11 to 13 men and 6 to 8 teams.

Table VII.

Harvest Cost Per Acre For Grain Cut with Tractor Drawn Binder and Threshed with Grain Separator, 1928.

	Wheat		Barley		Oats	
	Quantity per Acre	Cost Per Acre	Quantity Per Acre	Cost Per Acre	Quantity Per Acre	Cost Per Acre
Man labor cutting and shocking (1) hours	2.24	$ 0.79	2.55	$0.92	2.33	$0.77
Tractor for cutting (2) hours	.52	.52	.54	.54	.45	.45
Twine (3) - Pounds	2.1	.26	2.1	.26	2.7	.32
Depreciation and Interest on binder	--	.25	--	.33	--	.25
Man labor threshing (1) hours	2.57	.89	3.23	1.12	3.10	1.00
Horse labor threshing (4) hours	2.69	.32	3.44	.41	3.33	.40
Thresh bill (5)	--	1.12	--	1.40	--	1.56
Total cost	--	$4.15	--	$4.98	--	$4.75

The depreciation on the binder was figured on the basis of a 12 year life, (6) and to make comparison possible with the combine it was assumed that both binder and combine were new at the same time. Interest was charged at 6% on the first cost the first year and on the depreciated value the second year. The depreciation and interest cost of the stationary thresher is included in the per bushel threshing charge. The amount of twine used was based on information obtained from farm costs studies in Ohio.

Approximately one man hour per acre was required to harvest an acre of grain with a 10-foot combine, and 5 man hours were required to harvest an acre of grain with a tractor drawn binder and stationary thresher. A crew of 2 men was as large a crew as was needed to accomplish the task with the com-

(1) Labor charge for cutting grain same as rate for combining which was wage the farmer actually paid or the wage that it would have been necessary to pay.
(2) Tractor work cutting grain charged at $1.00 per hour, all costs included.
(3) Twine charged at 12 cents per pound.
(4) Horse labor charged at 12 cents per hour.
(5) Average rate of charge for threshing in 1928 as reported by farmers interviewed- wheat, 6.2¢; barley, 5.6¢; and oats, 3.8¢.
(6) Average life of binder based on information obtained from farm cost studies in Ohio.

bine, whereas by the binder thresher method a crew of 4 or 5 men are needed to cut and shock the grain and 11 to 13 to thresh it. In terms of machine hours per acre, (actual time, combine, or binder and thresher are operated) the binder thresher method requires 50 per cent more time per acre than the combine. The total cost per acre for the binder thresher method was by this comparison, 85 per cent greater on the average than the combine method of harvesting grain.

Table VIII.

Combine and Binder-Thresher Operation Costs and Labor Requirements per Acre, 1928.

	Wheat	Barley	Oats
Cost per acre			
Combine	$2.35	$2.45	$2.66
Binder-thresher	$4.15	$4.98	$4.75
Hours Labor per acre			
Combine			
Man labor	.96	.99	1.15
Tractor	.48	.51	.59
Binder-thresher			
Man labor	4.81	5.78	5.43
Tractor	.52	.54	.45
Horse labor	2.69	3.44	3.33

Custom Work With Combine

In 1928, 29 per cent of the acres harvested with a combine was custom work. Forty-six of the seventy-five farmers interviewed did some custom work, The amount ranging from 8 acres to over 300 and averaging 90 acres per machine. Of the 46 combines doing custom work only 3 were operated entirely as custom machines and the average acreage harvested by these three machines was 257. The rate of charge for custom work varied from $1.50 to $5.00 per acre although the most common charges were $3.00, $3.50 and $4.00 per acre.

One man charged 10 cents per bushel and another set a flat rate of $2.00 per acre plus 10 cents per bushel.

Hours Combine Was Used Per Day

The number of hours that a combine could be operated out of each 24 varied greatly. It was necessary to wait until the grain was sufficiently dry to thresh, and operations stopped when it began to get damp in the evening. How early it was possible to start depended on the weather conditions, amount of green material, and condition of the grain whether standing or lodged and the same things apply to stopping in the evening. The average starting time was 10 A.M. and stopping time at 6 P.M. making possible 8 hours of harvest. Although the average starting time and stopping time made possible 8 hours of harvest, there were many days when conditions were such that only a few hours of harvesting were possible others when the combine could not be operated and still others when it was possible to work more than 8 hours, if the machine was stopped at noon, the hours of actual harvest time were still further reduced.

The Effect of a Rain on Combine Operations

A rain or damp foggy weather that made the grain too tough for complete separation halted combine operation; the same held true for the stationary thresher. The length of time delayed because of a rain depended on the weather following. If there was a sun and wind after the rain, often combine operations were started before the stationary thresher because the standing grain dried faster than grain in shocks. A light rain often did not dampen shocked grain sufficiently to stop the stationary thresher and yet the combine was not able to operate until the grain dried. The length of time required before operations could be resumed depended entirely on the weather conditions following the rain.

Extra Time Required For Grain to Ripen Before It Can Be Combined

The number of days combine harvesting was reported to have been delayed after a binder could have been started, ranged from 2 to 21 days for wheat, 2 to 12 days for barley, and 2 to 10 days for oats. Although the lapse of time varied widely, the majority of the farmers started to combine their wheat 7 or 8 days and barley and oats 5 to 7 days after the binder could have been started.

Moisture Content and Keeping Qualities of Combined Grain

When the moisture content of grain is 14 per cent or below it can be stored with safety. Some of the farms had the moisture content of their grain tested before starting, others depended on experience to tell them when the grain was ready to bin. The moisture content of grain varied from day to day with the weather condition, with the amount of green material that was run through the combine and with the amount of green weed seeds and stems that remain in with the threshed grain. Some farmers found it necessary to scatter the grain thinly over a large floor to keep it from heating and spoiling and others found it necessary to stir the grain after combining to prevent heating, while still others had no trouble and reported high quality grain. Where the grain was sold direct from the machine a few farmers were docked because of the high moisture content. Farmers that had the price cut on the grain sold direct expressed the opinion that the extra weight of the grain made up for the loss.

Harvesting Losses

No extended study has as yet been made in Ohio of the amount of grain lost by the different methods of harvesting. The Agricultural Engineering Department of the Ohio State University is making definite plans for such a study during the present harvest season and until the results of this study are available no satisfactory information will be available as to the com-

parative grain losses by the combine and binder thresher method of harvesting in Ohio.

Weeds

The effect upon combining of weeds and other green material, as sweet clover and grasses sown in the grain, depends on the height of the green plants and their abundance. During the 1928 season considerable difficulty was encountered with green material, most of which was sweet clover, which because of favorable weather had made a large growth by the time the grain was ready to combine. If the grain stood up and the straw had good length, very little trouble was encountered, but where the grain had lodged or straw broken it was necessary to run the sickle so low to get all the grain that much green material was often out with the grain and run through the machine. This often resulted in the combine chocking and plugging and in addition the grain became damp and there was some tendency toward poor cleaning and loss of grain.

The weed problem in the more humid areas of the country is one that causes both manufacturers and operators much concern. In an effort to meet the problem of green material a machine has been developed which cuts the grain and drops it in windrows. After it has been allowed to dry in the windrows.the grain is picked up by an attachment and run through the combine. This method has the advantage of shortening the period of delay caused by waiting for the grain to ripen, and is believed by many to be the solution to the weed problem. As well as having advantages it has the disadvantage of a still larger investment and necessitates two operations whereas the present combine does the job in one. In 1928 there were two farmers in the state that used windrow machines.

Advantages and Disadvantages of the Combine

Most of the combine owners interviewed during the past winter were very well satisfied with the combine and believed that it will be a success

in Ohio. The combine owners were asked to state the advantages and disadvantages of the combine. The following are some of the statements given.

Advantages -

1. Lowers harvesting costs.
2. Reduces harvest labor both in time and men.
3. Allows more time for other things.
4. Makes one independent of exchange labor.
5. For the grain farmer, spreads straw on fields.
6. Picks up down grain better than binder.
7. Reduces cost and number of harvest meals.

Disadvantages -

1. Loss of straw.
2. Large investment.
3. Difficulty in handling green material.
4. Uncertainty of weather.

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